UNITED STATES PATENT APPLICATION

FOR

IMPLEMENTATION OF HPNA 2.0 NETWORK STATES IN HARDWARE

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IMPLEMENTATION OF HPNA 2.0 NETWORK STATES
IN HARDWARE

FIELD OF THE INVENTION

The present invention relates to computer network, and more particularly to the

handling of network states in a home phone line network.

5   ## BACKGROUND OF THE INVENTION

Home networks are becoming more common and desirable for connecting computers

within a home. One type of home network is the home phone line network which uses

telephone lines typically installed in residence homes for communication between computers

in the home.

10   Figure 1 illustrates a home phone line network. The Home Phone Line Networking

Alliance (HPNA) has published a specification to standardize the behavior of home phone

line networks. The current HPNA specification is version 2.0 ("HPNA 2.0"). The network

comprises a control chip 100. The chip 100 further comprises a Media Independent

Interface (MII) 106, a Media Access Control (MAC) 108, and a Physical Layer (PHY) 110.

15   The chip 100 implements HPNA 2.0. The chip 100 receives a signal containing data packets

through the telephone wires via a phone jack 102. There is an analog front end (AFE) 104

which processes the signal between the chip 100 and the telephone wires. The chip 100 then

processes the packets received in the signal from the AFE 104, and outputs a signal to the

Host MAC 112.

20   Under HPNA 2.0, stations in the network supports a 10 megabits-per-second (mbps)

data rate and/or a 1 mbps data rate, depending on the network state of the station. Such

stations are referred to as "10M8 stations". Stations implemented under a previous version of the HPNA specification ("HPNA 1.x") supported only the 1 mbps data rate. Such stations are referred to as "1M8 stations".

There are three possible network states for 10M8 stations: V1M2 mode, 1M8 mode, and 10M8 mode. 10M8 stations in the 1M8 mode transmit only 1M8 format frames, with a private communication (PCOM) field set to 1 or 2. The PCOM is a field in the frame. Its information is used by the PHY 110 in node-to-node communications. The PCOM field is set as follows:

PCOM = 0 refers to a 1M8 station;

PCOM = 1 refers to a 10M8 station functioning in V1M2 mode or 1M8 mode if V1_DETECTED is not asserted; and

PCOM = 2 indicates a 10M8 station functioning in V1M2 mode or 1M8 mode if V1_DETECTED is asserted.

The signal, V1_DETECTED, is described further below.

10M8 stations in the 10M8 mode transmit only 10M8 format frames. 10M8 stations in the V1M2 mode transmit either 1M8 format frames to 1M8 stations with a PCOM set to 1 or 2, or 10M8 compatible format frames to 10M8 stations. The 10M8 compatible frame contains a gap within the data frames. This "gap frame" provides interoperability between the format frames under HPNA 2.0 and HPNA 1.x.

The following equations set forth the three modes possible for a 10M8 station:

V1M2_MODE   := (*not* ConfigV1) *and* ((*not* ConfigV2) *or* ConfigV1M2) *and*

$$(\text{ConfigV1M2 or V1\_DETECTED or V1\_SIGNALED})$$

1M8_MODE   := ConfigV1

10M8_MODE   := *not* (V1M2_MODE *or* 1M8_MODE)

ConfigV1M2 is a signal which forces a station into the V1M2 mode. ConfigV1 is a signal which forces a station into the 1M8 mode. ConfigV2 is a signal which forces a station into the V1M2 mode.

V1_DETECTED is a signal which is asserted when a 10M8 station, while in 10M8 Mode and with Link Integrity Status = DOWN, detects a 1M8 format frame with a PCOM = 1. V1_DETECED is also asserted when a 10M8 station detects a 1M8 format frame with a PCOM = 0. The Link Integrity Status indicates whether or not the station is connected with another station. If the station is disconnected, then the Link Integrity Status = DOWN. If the station is connected, then the Link Integrity Status = UP.

V1_SIGNALED is a signal which is asserted when a 10M8 station detects or transmits a 1M8 format frame with a PCOM = 2.

Conventionally, the three network states under HPNA 2.0 are implemented in software. However, the response time may be slow.

Accordingly, there exists a need for an implementation of the HPNA 2.0 network states in hardware. The present invention addresses such a need.

SUMMARY OF THE INVENTION

A network state machine which implements the three network states of HPNA 2.0 in

hardware has been disclosed. The network state machine implements the three network states using two network states. When a station is in the V1M2 mode, instead of transmitting this frame in the 10M8 format frame with the gap frame, the frame is transmitted in the 1M8 format frame without any gaps in the frame. By implementing this in hardware, the network state machine has a faster response time.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 illustrates a home phone line network.

Figure 2 illustrates a preferred embodiment of the Media Access Control in accordance with the present invention.

Figure 3 is a flow diagram illustrating an implementation in hardware of the 10M8 mode by the network state machine in accordance with the present invention.

Figure 4 is a flow diagram illustrating an implementation in hardware of the 1M8 mode by the network state machine in accordance with the present invention.

DETAILED DESCRIPTION

The present invention provides an implementation of the HPNA 2.0 network states in hardware. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiment will be readily apparent to those skilled in the art and the generic principles herein may be applied to other embodiments. Thus, the present invention is not intended to be limited to the embodiment

shown but is to be accorded the widest scope consistent with the principles and features described herein.

To more particularly describe the features of the present invention, please refer to Figures 2 through 4 in conjunction with the discussion below.

Figure 2 illustrates a preferred embodiment of the MAC 108 in accordance with the present invention. The MAC 108 comprises a Receive Data Path 202, a Transmit Data Path 204, a Distributed Fair Priority Queuing (DFPQ) 206, a Binary Exponential Backoff (BEB) 208, a Link Integrity 210, a Network State 212, a Rate Request Control Frame (RRCF) 214, a plurality of registers and Management Information Base (MIB) counters 216.

The Receive Data Path 202 receives data packets from the PHY 110 and sends data packets to the MII 106. In the preferred embodiment, after each data packet sent by the Receive Data Path 202, another packet, referred to herein as a "frame status frame", is sent immediately following. The frame status frame contains certain status information required by subsequent processes.

The Transmit Data Path 204, which receives data packets from the MII 106 and transmits them to the PHY 110.

The DFPQ 206 and the BEB 208 provide collision resolution. The DFPQ 206 provides collision resolution for the 10 mpbs data rate, while the BEB 208 provides collision resolution for the 1 mpbs data rate. In the preferred embodiment, the PHY 110 will provide a collision detect signal. Either the DFPQ 206 or the BEB 208 will then attempt to resolve the collision.

The Link Integrity 210 monitors the physical network conditions. In the preferred

embodiment, the Link Integrity 210 updates a link status bit in a link register. The Link

Integrity 210 also sends link packets in accordance with HPNA 2.0.

The RRCF block 214 sends a RRCF whenever the MAC 108 transitions between

5   data rates. The RRCF is used to perform the rate negotiation function, i.e., to determine

what is the data rate to communicate between different stations in a home phone line

network.

The registers and MIB counters 216 provides programmability to the MAC 108 and

handles error event counting.

10   The Network State 212 in accordance with the present invention monitors the current

mode of the MAC 108, i.e., whether the MAC 108 is operating in the 1M8 mode, the V1M2

mode, or the 10M8 mode.

To support the three network states under HPNA 2.0 using two network states, the

three network state equations for V1M2_MODE, 1M8_MODE, and 10M8_MODE, set forth

15   in the Background, are collapsed into two equations. To accomplished this, when a 10M8

station is in the V1M2 mode, instead of transmitting this frame in the 10M8 compatible

format, the frame is transmitted in the 1M8 format frame without any gaps in the frame.

Thus, the following equations apply:

20   V1M2_MODE = 1M8_MODE

ConfigV1M2 = ConfigV1

Using the above equations, the three network state equations set forth in HPNA 2.0 becomes the following:

1M8_MODE   :=   (ConfigV1 *or* ConfigV1M2) or (*not* ConfigV2 *and* (V1_SIGNALED *or* V1_DETECTED)

10M8_MODE :=   *not* 1M8_MODE

The definitions for ConfigV1, ConfigV1M2, ConfigV2, V1_SIGNALED, and V1_DETECTED remain unchanged.

In this manner, the three network states of HPNA 2.0 is supported using two network states.

Figure 3 is a flow diagram illustrating an implementation in hardware of the 10M8 mode by the network state machine in accordance with the present invention. A 10M8 station is currently in the 10M8 mode when the M10M8_S signal is asserted, via step 302. Next, if the MTX_LINK signal is not asserted and the RX_DET_1 signal is asserted, via step 304, then the SET_V1_DETECTED_P1 signal is asserted, via step 314. The MTX_LINK signal is asserted when the Link Integrity status is "UP" and not asserted when the status is "DOWN". The RX_DET_1 signal is asserted when the 10M8 station receive detects a 1M8 frame with a PCOM = 1. The assertion of the SET_V1_DETECTED_P1 asserts the V1_DETECTED signal with a PCOM value of "1".

If the MTX_LINK signal is asserted or the RX_DET_1 signal is not asserted, then the Network State 212 determines if the RX_DET_0 signal is asserted, via step 306. The RX_DET_0 signal is asserted when the 10M8 station receive detects a 1M8 frame with a PCOM = 0. If RX_DET_0 signal is asserted, then the SET_V1_DETECTED_P0 signal is

asserted, via step 316. The assertion of the SET_V1_DETECTED_P0 signal asserts the V1_DETECTED signal with a PCOM = 0.

If the RX_DET_0 signal is not asserted, then the Network State 212 determines if either the RX_DET_2 signal or the TX_DET_2 signal is asserted, via step 308. The RX_DET_2 signal is asserted when the 10M8 station receive detects a 1M8 frame with a PCOM = 2. The TX_DET_2 signal is asserted when the 10M8 station transmit detects a 1M8 frame with a PCOM = 2. If either of these signals is asserted, then the SET_V1_SIGNALED signal is asserted, via step 318. The asserted SET_V1_SIGNALED signal asserts the V1_SIGNALED signal.

If neither the RX_DET_2 nor the TX_DET_2 signal is asserted, then the Network State 212 determines if the FORCE_V1P0 signal is asserted, or the CONFIG_V1 signal is asserted, or if there is a combination of the CONFIG_V2 signal not being asserted and the V1_DET_SIG signal being asserted, via step 310. The FORCE_V1P0 signal is asserted when the 10M8 station is to be forced into the 1M8 mode with a PCOM = 0. The CONFIG_V1 signal is asserted when the 10M8 station is to be forced into the 1M8 mode with a PCOM = 1. The CONFIG_V2 signal is asserted when the 10M8 station is to be forced into the 10M8 mode. The V1_DET_ SIG signal is asserted when either the V1_DETECTED or the V1_SIGNALED signals are asserted. Step 310 implements the following equation for the 1M8 mode, described above:

1M8_MODE := (ConfigV1 *or* ConfigV1M2) or (*not* ConfigV2 *and* (V1_SIGNALED *or* V1_DETECTED)

If step 310 is determined to be "false", then the 10M8 station continues to function in the 10M8 mode. If step 310 is determined to be "true", then the 10M8 station is forced into

the 1M8 mode. In doing so, the SEND_RRCF and the RST_RRCF signals are asserted, via step 312. The asserted SEND_RRCF signal causes a RRCF to be sent. After the RRCF is sent, counters in the RRCF 214 is reset by asserting the RST_RRCF signal.

If either the V1_DETECTED or the V1_SIGNALED signals are asserted, via step 314-318, then the Network State 212 if the FORCE_V1P0 or the CONFIG_V1 signal is asserted or if the CONFIG_V2 signal is not asserted, via step 320. Step 320 implements the same equation for the 1M8 mode as step 310, however, since it is already known that either the V1_DETECTED or the V1_SIGNALED signals have been asserted, that determination is not required at step 320. If step 320 is determined to be "false", then the 10M8 station continues to function in the 10M8 mode. If step 320 is determined to be "true", then the 10M8 station is forced into the 1M8 mode. In doing so, the SEND_RRCF and the RST_RRCF signals are asserted, via step 322.

Figure 4 is a flow diagram illustrating an implementation in hardware of the 1M8 mode by the network state machine in accordance with the present invention. The 10M8 station is currently in the 1M8 mode when the M1M8_S signal is asserted, via step 402. Next, the counters in the RRCF 214 are enabled by asserting the EN_RRCF signal, via step 404. Next, if the RX_DET_0 signal is asserted, via step 406, then the SET_V1_DETECTED_P0 signal is asserted, via step 416.

If the RX_DET_0 signal is not asserted, then the Network State 212 determines if either the RX_DET_2 signal or the TX_DET_2 signal is asserted, via step 408. If either of these signals is asserted, then the SET_V1_SIGNALED signal is asserted, via step 418.

If neither the RX_DET_2 nor the TX_DET_2 signal is asserted, then the Network

State 212 determines if the FORCE_V1P0 signal is asserted, or the CONFIG_V1 signal is

asserted, or if there is a combination of the CONFIG_V2 signal not being asserted and the

V1_DET_SIG signal being asserted, via step 410. As with step 310 in Figure 3, step 410

implements the following equation for the 1M8 mode, described above:

$$\text{1M8\_MODE} \quad := \quad (\text{ConfigV1 } or \text{ ConfigV1M2}) \text{ or } (not \text{ ConfigV2 } and$$
$$(\text{V1\_SIGNALED } or \text{ V1\_DETECTED})$$

If step 410 is determined to be "false", then the 10M8 station resets the counters in

the RRCF 214 by asserting the RST_RRCF signal, via step 428, and changes to the 10M8

mode. If step 410 is determined to be "true", then the Network State 212 determines if the

RRCF timer has overflowed by determining if the RRCF_TMO signal is asserted, via step

412. The RRCF_TMO signal is asserted when the life-span of the last RRCF has expired. If

the RCF_TMO signal is asserted, then the SEND_RRCF and the RST_RRCF signals are

asserted to send the RRCF again, via step 414. The 10M8 station then continues in the 1M8

mode.

If either the V1_DETECTED or the V1_SIGNALED signals are asserted, via step

416-418, then the Network State 212 determines if the FORCE_V1P0 or the CONFIG_V1

signal is asserted or if the CONFIG_V2 signal is not asserted, via step 420. As with step 320

of Figure 3, step 420 implements the same equation for the 1M8 mode as step 410, however,

since it is already known that either the V1_DETECTED or the V1_SIGNALED signals

have been asserted, that determination is not required at step 420. If step 420 is determined

to be "false", then the 10M8 station resets the counters in the RRCF 214 by asserting the

RST_RRCF signal, via step 426, and changes to the 10M8 mode. If step 420 is determined

to be "true", then the 10M8 station continues in the 1M8 mode. The SEND_RRCF and the RST_RRCF signals are asserted, via step 424, if the RRCF_TMO signal is asserted, via step 422.

A network state machine which implements the three network states of HPNA 2.0 in hardware has been disclosed. The network state machine implements the three network states using two network states. When a station is in the V1M2 mode, instead of transmitting this frame in the 10M8 format frame with the gap frame, the frame is transmitted in the 1M8 format frame without any gaps in the frame. By implementing this in hardware, the network state machine has a faster response time.

Although the present invention has been described in accordance with the embodiments shown, one of ordinary skill in the art will readily recognize that there could be variations to the embodiments and those variations would be within the spirit and scope of the present invention. Accordingly, many modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the appended claims.